DOCUMENT RESUME

ED 126 871 IR 003 777

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TITLE Report on Children's Television Viewing Strategies.
INSTITUTION Children's Television Workshop, New York, N.Y.
PUB DATE 10 Oct 72
NOTE 17p.; Not available in hard copy due to marginal legibility of original document

EDRS PRICE MF-$0.83 Plus Postage. HC Not Available from EDRS.
DESCRIPTORS Elementary Education; Eye Fixations; *Eye Movements; Eyes; *Learning Modalities; *Reading Processes; *Reading Research; *Reading Skills; Television Research; Visual Discrimination; Visual Learning; *Visual Perception; Visual Stimuli
IDENTIFIERS Childrens Television Workshop

ABSTRACT

Special equipment was used to record the eye movement patterns of 60 children enrolled in a reading clinic. There were 20 children in each of three groups: good readers, slow readers, and non-readers. The children were shown printed material on a screen accompanied by action sequences and voice recordings similar to what they might see on television. Experimental findings showed that good readers looked quickly at and accurately processed reading material presented on a screen. They were not negatively affected by action or distraction. Slow readers were often distracted and frequently failed to read past the first two or three letters. They looked more often at the speaker and needed more time to fixate on the material. Non-readers displayed random looking behavior at printed material, and they were strongly drawn by action on the screen. Orienting to new stimuli was slower for non-readers, particularly if the message of the words was not carried in the action. The results of this research were incorporated into eight suggestions for children's television programing. (CH)

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REPORT ON CHILDREN'S TELEVISION VIEWING STRATEGIES

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REPORT ON CHILDREN'S TELEVISION VIEWING STRATEGIES

1. Review of Purpose of the Study

   (a) To assess the looking and attention behaviour of children of different reading levels to various segments of the Electric Company - a production of Children's Television Workshop.

   (b) To provide suggestions for positioning, duration and action of reading segments based upon eye movement recordings.

2. Brief Preview of the Literature on Reading and Eye Movement Patterns

Eye Movements

The human eye has long been regarded as a mirror of the soul. And English literature is replete with characters whose eyes mark them as villains or heroes, as fools or intellectual giants. Yet there does seem to be more than tradition or fiction in the relevance of the eye and its movements to the human personality and intellect, since in recent years it has been the subject of considerable research, not only by scientists interested in its physiology, but also by psychologists interested in investigating its relationship to, among other things, cognitive functioning, aesthetic appreciation, and schizophrenia. In line with this, three questions deserve consideration. First, what role do EMs play in vision? Second, what are the basic characteristics of EMs? And third, what implications do they have for psychological cognitive research?

As far as perceiving goes, if one is to fixate on something (look at it) he must move his eyes so that the image falls on the fovea. This area, actually smaller than the head of a pin, is the only region in the retina where receptor cells are sufficiently concentrated to

produce detailed vision. More specifically, the fovea subtends an angle of about two degress, whereas the retina as a whole covers a visual angle of approximately 240 degrees. Thus, not more than a thousandth of the total viewing area can be perceived in sharp focus at once. In spite of this, the eye is capable of rapidly distinguishing details within a stimulus field. This occurs because most of the time our eyes are jumping about in the visual field, with the two foveae receiving first details from one part of the field and then another.

The rapid jump the eye makes as it moves from one fixation to the next is the most common type of EM, and is referred to as a saccade, or saccadic EM. These fixations usually last less than half of a second, although their duration may depend on the viewing field and/or the psychological task, suggesting, in part, that they are cognitively controlled. The jump between fixations usually takes only a few milliseconds with vision being reduced during the saccade and immediately preceding it. The actual speed of the jump depends upon its length and direction, although it may also vary as a function of the individual. If the fovea is not on "target" at the end of the saccade, it adjusts accordingly by additional EMs more molecular in nature. The path between two fixations may be straight, curved or even hooked, but once started cannot be changed.

Since the eye moves so quickly and frequently, EMPs can only be accurately ascertained (recorded) by precision instruments. Several methods are available for recording EMs. Among them there are contact lenses, suction cups, photo-electric devices, electro-oculography and

corneal reflection. The latter technique was used in the present study. Briefly, it involves photographing a bright spot reflected off the convex surface of the cornea of the eye. This spot appears to move because the radius of curvature of the cornea is smaller than the radius of the spherical eyeball and the angle of reflection changes as the eyeball rotates. These movements are then correlated with movements within the line of sight.

Reading Research

Although it is difficult to record accurately EMs of young children, especially those younger than six years of age, a number of studies deserve consideration. One of the few dealing with children three to six years of age is the research published by Zaporozhets and Zinchenko (1966). Using complex stimuli, the authors report that a relationship exists between EMs and the development of perceptual activity, such that the isolation of a specific sensory content becomes increasingly commensurate with the material and task concerned as the child becomes older. Zaporozhets and Zinchenko's premise, however, is difficult to assess (as are most Russian translations) since they fail to present in detail their methodological procedure.

Gilbert (1953) obtained EM measures for frequency of fixation and pause duration for children from Grades 1 to 9, and found a steady growth in ocular motor proficiency. His data is similar to that reported by Morse (1951) who found more efficient patterns of EM for children in upper grades. Dunn (1954), in comparing EMs of retarded and normal boys of similar mental age engaged in reading tasks, reported

no significant difference between rate of reading, fixations and regressions between the groups. He does not report comparisons between the retardates and boys of the same chronological age, but it may be assumed that they would display differences similar to those found by Gilbert (1953) and Morse (1951) between normal children of different chronological (and by implication, mental) age. Once again it might be argued that the retarded group's EMs reflect their inability to read at their chronological age level, rather than this being a causative factor in their mental development. Blackhurst and Radke (1966), however, report that mentally retarded children do have difficulty in fixating objects and controlling visual search behaviour, while Rosenberg (1961) demonstrated that severely retarded patients took longer to detect and select a nonsense shape from a matrix than did moderately retarded patients.

Mackworth and Bruner (1966) have also reported differences in EMs of children and adults, but this time in detection and selection of visual information. They concluded that the differences were developmental in nature and related to informative search strategies of the subjects. More specifically, they found that EMPs of children were less consistent than those of adults, and that children exhibited "piecemeal perception" by dwelling on "unimportant" details. Their eye tracks also tended to trace simple contours and to pinpoint on details, thus, according to Mackworth (1967), contradicting a theory of global perception in children.

A relation between EM output and intellectual behaviour in

normal children was reported by Lorens and Darrow (1962). Although their sample was very small (10), Lorens and Darrow found significant rate increase in EMs during mental multiplication. The change in rate was not related to changes in heart rate or conduction level.

Luborsky, Blinder and Mackworth (1964) have also studied cognition and EMs. They focussed on inspection time of a visual field in relation to the recall of that part of the stimulus field attended to. In so doing they were able to link the time of inspection of part of the visual field with accuracy of recall of perceptual images; the greater the inspection time the greater the recall. Teichner and Price (1966) suggest that the finding of a visual pattern in an array of stimuli is a problem-solving or concept formation task involving successive data inputs represented by successive eye fixations. And, they hypothesized that EMs resulting in the obtaining of new information would represent a data acquisition process which, in turn, might be divisible into hypothesis testing and non-directed movements. Using Simon and Kotosky's (1963) letter sequence, Teichner and Price tested 10 under-graduate males and found indications that correct solutions to sequence tasks were accompanied by more systematic eye movements and increased attention to detail. Similarly, Ford, White and Lichtenstein (1959) concluded, in their study of EMs during free search, that duration varies with the difficulty of the field and that specific search patterns can be isolated from EM recordings. Their findings are consistent with those reported by Zaporozhets and Zinchenko (1966), Mackworth and Bruner (1966) and Conklin, Muir and Boersma (1968).

In the Conklin et al study, EMPs of high and low scorers on a test of field dependency-independency were compared. Significant differences were found in track length and in Mackworth and Bruner's informative search score variable. Sex differences and duration of EMs were not significantly different between the groups. The authors concluded that field independent subjects employed "better" search patterns than did field dependent subjects. Their findings are important in relation to the present study, in that they suggest a reflection of cognitive processing EMPs.

Especially relevant to the present study are the following points. First, EMs (points of fixation), using the principle of corneal reflection, can now be reliably recorded (Mackworth, 1967). Second, "eye-movements reflect (underscore added) the human thought process so that the observer's thought may be followed to some extent from records of eye movements ... " (Yarbus, 1967, p. 190). Third, the organism is largely unaware of EMs made in deriving and processing information upon which subsequent actions are based (Thomas, 1963). And fourth, EMs are an aspect of human behaviour not easily analyzed by others, and, consequently, less subject to control by the organism through factors arising out of a desire for social conformity (Webb, Matheny and Larson, 1963).

Apparatus

The Eye Movement Recorder

In the present study a Polymetrics Products Eye Movement Recorder (Model V-1164-1), employing the principle of corneal reflection,

was used to obtain permanent photographic records of EMPs. Full technical data on the apparatus may be obtained from the designer's article (Mackworth, 1967) or from the manufacturer[3].

In brief, however, the Eye Movement Recorder records EMPs by means of a Pathé "Professional" 16 mm reflex movie camera on film at a constant exposure rate of 10 frames per second. Foot and hand controls permitted the simultaneous recording of EMs in conjunction with the presentation of stimulus material. The stimuli appear approximatley 26.5 inches (variations occur due to different subject skull formation) from the subject's eyes within a useable viewing area of 7.8 inches by 7.8 inches. Recording accuracy is within plus or minus one degree when subjects view a 20 degrees wide and 20 degrees high display. Thus, eye-spot accuracy can be ascertained within an area about the size of an American 10¢ piece.

In operation the recorder is mounted on a wishbone-shaped base plate supported by a heavy bench. The subject, seated on an adjustable chair, views the stimulus display with both eyes. Foam rubber supports were used to make the apparatus and chair more comfortable for young children. A metal tube was also added to the focussing device in order to speed the location of the corneal reflection spot.

Additional Experimental Apparatus

A Sony ½" wide video tape recorder and 9" monitor were

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[3] Polymetric Company, 1415 Park Avenue, Hoboken, New Jersey, U.S.A. 07030.

positioned on the frame so that the viewing area was perpendicular to the line of vision. Viewing distance and light intensity were constant for all subjects. The stimulus material was placed so that the total possible viewing area on the monitor screen was used.

3. Research Design

(a) Sample:- 60 children (30 boys, 30 girls) aged between 9 years 2 months and 10 years 8 months. All are residents of Toronto and were included in the study after referral to a reading clinic or, in the case of group A, after random selection from a Toronto elementary school.

There were 20 children in each of 3 groups.

Group A were good readers, defined as children between 9 years and 11 years reading at least at grade level. In fact the mean reading level of this group was a little over 1.5 grades above grade levels.

Group B were slow readers, defined as children between 9 years and 11 years reading a level at least 2 years below grade level, but able to exceed end of grade 1 standard in reading. Mean grade level was 2.3 grades below expected grade placement.

Group C were non-readers, defined as children between 9 years and 11 years who failed to reach a grade one standard. Mean reading level was not established for this group as it would be of little informational value.

All assessments were made by a reading specialist using an informal reading inventory and the Durrell Analysis of Reading. Her assessments were cross validated by reference to referral data from teachers. Thus,

level of reading was taken to be the independent variable in the study. While female subjects were much more difficult to find than boys in Groups B and C, there was no statistically significant sex difference in level of reading performance in any of the groups.

Methodology

Since the study was essentially exploratory no directional hypotheses were set but the following parameters were used:-

(1) Reading level according to the three types described above.

(2) Position of print on the screen (high, low, left, right centre, etc.).

(3) Carriage of print (border boxes, animation, computer graphic, static).

(4) Voice over without action.

(5) Voice with action.

(6) Special effects.

Dependent variables were of two types quantitative and qualitative.

(1) Quantitative

(a) Number of fixations (positioning of the corneal reflection on a segment of the stimulus for a minumum of 1/10 second).

(b) Duration of fixations (length of average time of fixation on elements of the stimulus).

(c) Number of shifts between elements of the stimulus (the number of times the subject moves from the print to the action).

(d) Delay in orientation to onset of printed material.

(2) Qualitative

Development of "typical" eye movement patterns of samples of two groups of readers and one group of non-readers. The EMPs are taken as individual representations of viewing strategies so that each illustrates

the type of EMPs found in the groups. Analysis of variance was used to compare performance on each of the quantitative variables and in all of the following results the differences noted are significant at the .05 level or less. Most in fact reached the .01 level.

General Findings

The study indicated that there were differences in looking behaviour among all three groups. Good readers looked at all printed material immediately on presentation and displayed EMPs consistent with known reading patterns. They rarely referred back to words left on the screen but quickly looked at and probably accurately processed, changes in words, additions, deletions and expansions. They displayed rapid and concentrated eye movements on computer bridges and animations and oriented quickly to new material. It seems clear that position of the printed material at the level of difficulty presently being employed, is not a positive or negative variable to the good reader. In short he reads it, relates it to the action, has plenty of time for later referral and is not negatively affected by action or distraction.

The slow reader was not so quick to orient to printed material as was the good reader, but the difference was barely significant overall. However, there are some notable differences which shall be briefly reported now and can be seen in greater detail through illustration from the filmed recording of typical slow reader EMPs. (see accompanying film)

Slow readers were often distracted by action not directly related to or performed by the printed material. They often failed to proceed past the first two of three letters, displayed many regressive eye movement

patterns (backward looking), looked more often at the speaker than at the words, and, most markedly, seemed to require considerably more time to fixate on the material. While the measured fixation points indicated that EMPs appropriate to reading were employed by most children in Group B and that they were directed towards an attempt at reading, the looking often ceased before the whole word was fixated and, when looked at again, the fixations appeared once more at the beginning of the word. An interesting variation of this occurred, however, when computer formed words or animated words appeared. In these cases the carriage of the action in the word itself seemed to increase the number of left to right reading type fixations and also to provide a greater time of viewing to salient stimulus - i.e. the words themselves. On the basis of the results obtained there seems little doubt that high quality action sequences distract the slow reader and withdraw his attention from the word. This phenonmen might be related to the length of the word or to the length of the sentence. When action occurs with a short word, or letter group, that can be picked up in one or two fixations it is possible that this action could have facilitating effects as in the high concentration of fixations of all groups noted in the SOS sequence - one of the bits used in the study. But, when there are more than 3 or 4 letters the slow reader rarely gets further than the first two before his attention is drawn elsewhere. It is suspected that this will not be an easy problem to overcome.

Group C children (the non-readers) displayed notably different EMPs. Most striking feature was the random looking behaviour at printed material. There was some evidence of action causing attention to the print

but in this group the printed message seemed largely irrelevant. Whenever there was action on the screen the children of Group C were drawn strongly by that action. Whenever single words appeared EMPs fluctuated, showed only minor resemblance to reading-type patterns and often resulted in attacks being made on the word or sentence from the middle of the stimulus. Orienting to new stimuli was significantly slower in this group and one might again speculate that much more emphasis needs to be placed on the message material to attract attention to it. Where the message was carried in, or preferably, carried the action, fixation levels for Group C increased, duration of fixation increased and left to right movement was more often generated. Other interesting findings included a tendency observed in Group C children to fixate on a flashing letter longer than children in other groups and to ignore, or at least not fixate, the other letters in the word.

In interpreting the effect of presentation of materials on viewing strategy it is important to remember that the groups differed in their qualitative EMPs, and that the suggestions refer primarily to Group B (slow readers) and Group C (non-readers).

1. Carriage of Print

(a) Position of print on screen

(I) Central - preferably between eyes or at eye level is best in terms of number, duration and pattern.

(Ia) Balloons draw more attention than other.

(II) Bordering variations seemed to have little marked effect on looking behaviour.

(III) Zoom boxes were very effective and perhaps if placed at eye level of the actors (centre screen) would generate most activity.

(b) Type of print

(i) Static print proved least effective.

(ii) Flashing, stationery print drew looking behaviour.

(iii) Animated print was more effective than (i) or (ii).

*(iv) Computer print most effective especially when not in competition with live actors, but even then was more effective than static print.

* Note especially good with groups B and C.

(c) Special effects

(i) Animated and graphic presentations produced highest level of looking behaviour and reflected normal reading eye movements patterns in all groups.

(ii) Jump and cartoon sequences.

(a) "Jump" generated much looking behaviour. The position of the sign could be significant and minimum action by cartoon character could be a better possibility - all groups seemed to respond well to this approach.

Cartoon sequences tended to produce more fixations on the stimulus in Group B (KD5) than did live action, perhaps because of reduced distraction material - clearer lines, specific pointing etc. This is a difficult comparison to make, but incorporation of position, zoom, animation and minimal business might well be useful. Group C EMPs did not reach significant differences on this variable. Group A also failed to show differences similar to Group B.

(iii) Live action. Although not measured quantitatively there seems to be a high negative correlation between amount of action and message fixation. Live actors are most compelling and all groups attended much more to the actor than stimulus words whenever the two appeared simultaneously. When action occurred first, followed by the message, reading EMPs improved in Group B, the children attended directly to the stimulus and often displayed EMPs similar in type to Group A subjects. A similar phenomenon was observed when the message was greater in magnitude, dominant in intensity or preeminent in position.

Summary of suggestions for action

1. Avoid the use of live actors to present initially the new material. Live actors draw much attention and could be used better in recapitulation, practice or concept development segments. They appear to generate the highest level of attention to material when they are actively involved with the words or sentence segments but fall far short of the attention generated by computer or animated sequences in which the words themselves are active.
2. Considerably longer stimulus (word or sentence) exposure seems to be necessary, often the very slow movements of the eye indicated incomplete viewing of the words and the number of regressions suggested that the display time of each word or sentence segment could be doubled before over exposure would become a problem.
3. When the learning segment is first presented it would seem wise to center most attention upon it. Action around the segment effectively reduces the number of foveations upon it and seems especially to distract the subjects in Groups B and C.
4. When print appears either statically or dynamically with a live actor positioning at eye level seems most effective. Eye movements by the actors or gestures by them directly towards the print has a directive effect on the viewers. This can be used as an organizing device to set the viewer up for following teaching sequences.
5. Presentation of material in cartoon balloons tends to draw more looking than any other type of bordering. It is possible too that the formation of balloons from the speaker's mouth might also increase attention to

the stimulus. Special note might be made of zoom boxes which usually produced immediate centration on the sentence or word.

6. Perhaps the most significant finding was the attention getting power of animated words and computer bridges. As an introduction mechanism these approaches seem to work exceptionally well. They bring about immediate and accurate centration on the particular message and produce almost total centration time on the stimulus. In short the kids look at these about 100 per cent of the time.
7. There is some evidence to support leaving a clean, uncluttered image of the sentence or word on the screen after it has been taught to allow the slow or non-reader undistracted time to just look at it and probably to actually read it.
8. Action not directly centred on a word will almost certainly direct attention away from the word. At this time the child can profitably be given a rest from the strain that might be developed through high pressure attention - centration on the material to be learned.
   That is the entertainment segments need not always point at or to the learning material. There is some evidence that each group has cycles of attention and rest periods may increase the effectiveness of teaching segments.

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10/10/72